



25 MHz OSCILLOSCOPE

Model SO-4226

595-3896

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

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Precautions for Use

1. Inspect the shipping carton for serious shipping damage. If you notice damage, notify the carrier immediately.
2. Before you apply power to the Oscilloscope, make certain that the voltage selector plug on the rear panel has been inserted with the arrow marking in the direction of the proper line voltage. Also check the fuse to be sure it is of the proper rating.
3. Do not leave a bright beam on the CRT screen for long periods. This can cause permanent damage to the screen.
4. This instrument is convection-cooled. Always be sure the cooling vents are not blocked when you are operating it.
5. To insure stable operation over long periods of time, do not subject the Oscilloscope to vibration, direct sunlight, extreme temperature variations, high humidity, dust, or electromagnetic fields.

Table of Contents

INTRODUCTION	4	Horizontal/Time Base	18
SPECIFICATIONS	5	Calibrator	19
OPERATION	9	CRT Control	19
Controls and Connectors	9	Power Supply	19
Preliminary Operation	11	MAINTENANCE & ADJUSTMENTS	20
Triggering the Sweep	11	General Maintenance	20
X-Y Display Operation	12	Adjustment and Calibration	20
Voltage Measurements	12	Power Supply Adjustments	20
Dual Trace Display	12	CRT Circuit Adjustments	21
Synchronizing TV Signals	12	Vertical Axis Adjustments	21
Addition and Subtraction Operation	12	Horizontal Axis Adjustments	23
APPLICATIONS	13	SCHEMATICS	24
AC Voltage and Frequency		Vertical Amplifier Schematic,	
Measurements	13	Part 1	25
DC Voltage Measurement	13	Vertical Amplifier Schematic,	
AM Modulation Measurement	14	Part 2	26
Dual Trace Applications	14	Horizontal/Time Base Schematic,	
Comparison of Levels	14	Part 1	27
Checking Stereo Systems	14	Horizontal/Time Base Schematic,	
Servicing TV Sets	14	Part 2	28
Composite Video Analysis	15	Power Supply and CAL Schematic	29
Frequency Measurement With		HV Supply and CRT	
X-Y Method	15	Circuit Schematic	30
Phase Measurement	15	REPLACEMENT PARTS LIST	31
CIRCUIT DESCRIPTION	17	CUSTOMER SERVICE INFORMATION	32
General	17	WARRANTY	34
Vertical Amplifier	17		

INTRODUCTION

The vertical amplifiers on this dual-trace 25 MHz Oscilloscope have a calibrated sensitivity of 1 mV/division, a flat frequency response, and a smooth rolloff above 25 MHz. Maximum sweep speed is 20 ns/division. The 8 × 10 cm rectangular-type CRT with internal graticule gives the Oscilloscope a good look, while it is rugged enough for use in developmental work, on production lines, in maintenance, and in servicing. This scope also has the following features:

- Wide bandwidth and high sensitivity.
- High stability with low drift.
- Video delay line.
- A high-sensitivity X-Y mode.
- A Z-axis modulation input.
- A TV video sync filter.
- A trigger level lock function.
- Variable trigger hold-off.
- A single sweep function to display single-shot waveforms.
- A high brightness CRT.

SPECIFICATIONS

VERTICAL DEFLECTION

Deflection Factor	5 mV to 5 V/DIV $\pm$ 3%; 10 steps in 1-2-5 sequence with variable control.
Magnification	5 times (1 mV/DIV to 1 V/DIV at $\times$ 5 MAG).
Bandwidth (at -3dB)	DC: DC to 25 MHz (DC to 15 MHz at $\times$ 5 MAG). AC: 10 Hz to 25 MHz (10 Hz to 15 MHz at $\times$ 5 MAG).
Rise Time	Approximately 14 ns (approximately 23 ns at $\times$ 5 MAG).
Overshoot	Less than 3%.
Input Impedance	1 M Ω shunted by 25 ± 3 pF.
Maximum Input	400 V p-p, or 200 V (DC + AC peak).
Operating Modes	CH1, CH2, DUAL, and ADD.
Chop Frequency	Approximately 250 kHz.
Channel Separation	Over 60 dB at 50 kHz, 30 dB at 25 MHz.
CH1 Signal Output	Approximately 100 mV/DIV.
CH2 Polarity	Waveform inversion; variation less than 1 DIV.

HORIZONTAL DEFLECTION

Sweep Mode	AUTO, NORMAL and SINGLE.
Sweep Time	0.2 μ s to 0.5 s/DIV; 20 steps in 1-2-5 sequence with variable control and X-Y mode.
Magnification	$\times$ 10 (provides sweep time of 20 ns/DIV).
Sweep Time Accuracy	3% (6% at $\times$ 10 MAG).
Trigger Holdoff Time	Adjustable to longer than 5 times sweep length in 0.2 μ s/DIV to 1 ms/DIV ranges.
Linearity	3% (6% at $\times$ 10 MAG).

X-Y Operation Mode selected with SEC/DIV switch:
 CH1: X-axis.
 CH2: Y-axis.

Sensitivity Same as CH1 vertical axis.

Frequency Response DC to 1 MHz (– 3 dB).

TRIGGER

Source CH1, CH2, LINE and EXT.

Sensitivity INT: 0.5 DIV from DC to 15 MHz.
 1.5 DIV from DC to 25 MHz.
 EXT: 50 mV p-p from DC to 15 MHz.
 100 mV p-p from DC to 25 MHz.

Coupling AC, HF REJ, TV, and DC.
 HF REJ: Attenuates signal components above 50 kHz.

Polarity + or –.

Mode AUTO, NORM, and SINGLE.

Level Fix Preset level from 50 Hz to 25 MHz.

External Input Input Impedance: 1 M Ω , 30 pF.
 Maximum Input: 100 V (DC + AC peak).

INTENSITY MODULATION (Z-axis)

Input Voltage 3 V p-p or higher (Bright at negative-going input).

Input Resistance Approximately 5 k Ω .

Maximum Input 50 V p-p (DC + AC peak).

Frequency Range DC to 5 MHz.

GENERAL

CRT Accelerating Voltage	Approximately 2 kV.
Calibration Voltage	2 V p-p $\pm$ 2%, 1 kHz square wave (positive-going).
Power Requirements	117 V; 50/60 Hz; approximately 35 VA.
Fuse	1 A for 117 V.
Dimensions	12.4" W $\times$ 6.5" H $\times$ 17.1" D (315 $\times$ 165 $\times$ 435 mm).
Weight	Approximately 15.4 lbs (7 kg).

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligations to incorporate new features in products previously sold.

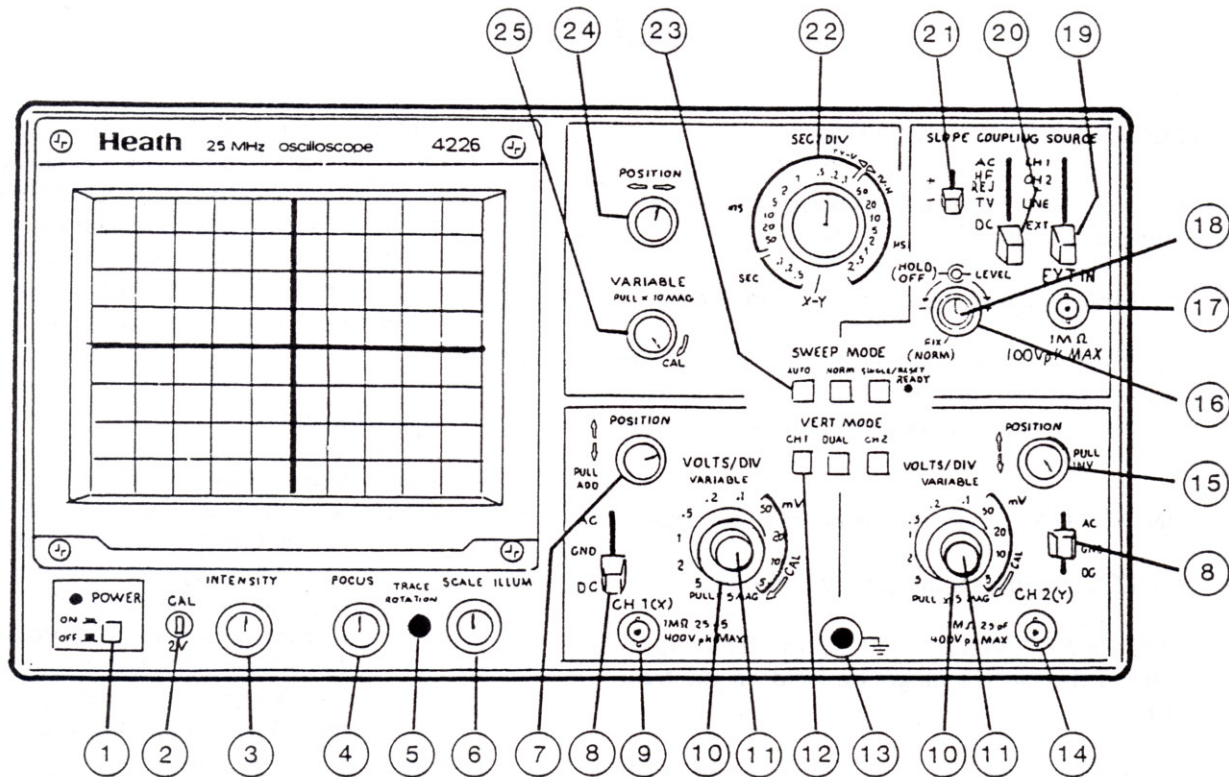


Figure 1

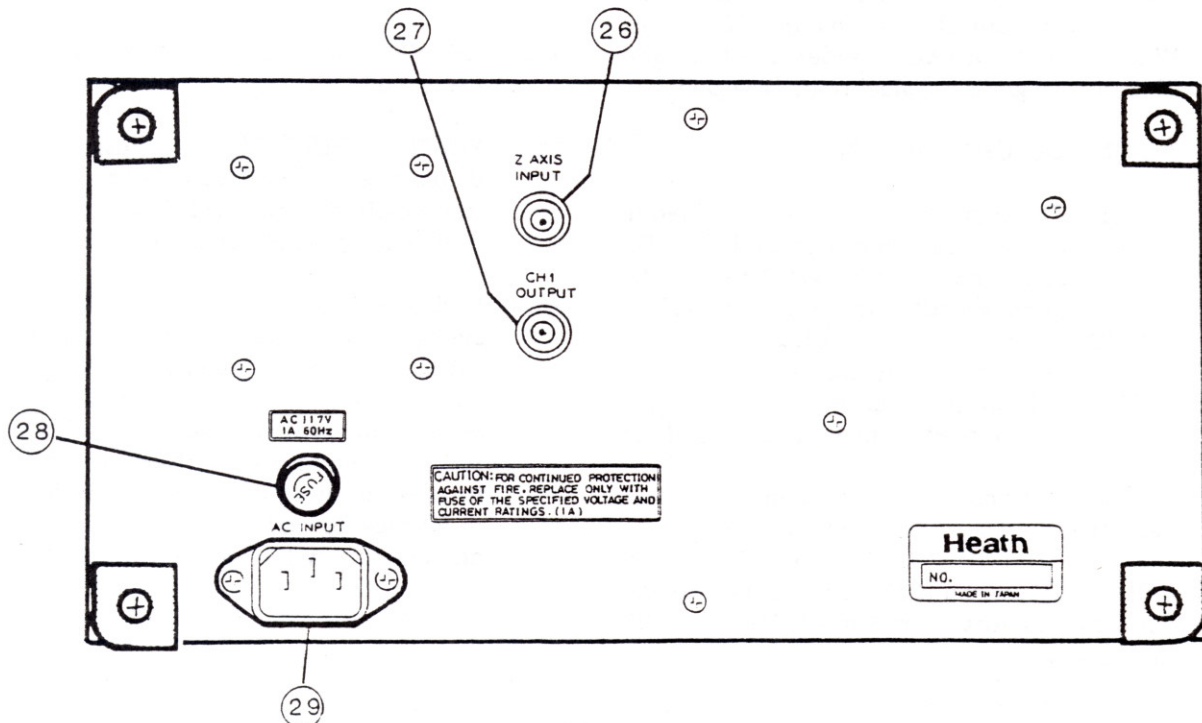


Figure 2

OPERATION

CONTROLS AND CONNECTORS

Refer to Figure 1 and Figure 2 as you read the following numbered paragraphs.

1. **POWER** — Turns the instrument on and off.
2. **CAL 2V terminal** — Provides a 1 kHz square wave output. It is useful for checking amplifier gain, waveform compensation of probes, etc.
3. **INTENSITY** — Adjusts the beam's brightness.
4. **FOCUS** — Adjusts the clarity of the beam.
5. **TRACE ROTATION** — Used to offset the effect of the earth's magnetic field on the trace line.
6. **SCALE ILLUM** — Adjusts the scale background light.
7. **POSITION/PULL ADD** — Positions the CH1 display vertically. In the X-Y mode, using EXT IN, this control positions the CH1 Y-axis. When pulled out (ADD mode), the CH1 and CH2 input signals are algebraically added.
8. **AC-GND-DC (CH1 and CH2)** —
 - AC: The signal is capacitively coupled to the vertical amplifier and any DC component is blocked. The low-frequency limit (-3dB) is about 10 Hz.
 - GND: Grounds the amplifier input and opens the input circuit.
 - DC: All components of the input signal are coupled to the vertical amplifier.
9. **CH1 (X) connector** — BNC connector connects the input signal to channel 1.
10. **VOLTS/DIV switch (CH1 and CH2)** — Selects deflection factors from 5 mV/DIV to 5 V/DIV in 10 steps.
11. **VARIABLE VOLTS/DIV control (CH1 and CH2)** — Variable controls for vertical attenuation. Provides continuously variable deflection factors (sensitivity) between the steps of the VOLTS/DIV switch. Normally they are set fully clockwise (CAL). When they are pulled out, the sensitivity is magnified by a factor of 5.
12. **VERT MODE selector** —
 - CH1: Displays Channel 1 only.
 - DUAL: A dual trace display switches between CH 1 and CH2, with alternate or chopped operation controlled by the SEC/DIV switch. Chopping occurs at approximately 250 kHz on the 0.5 s to 1 ms/DIV ranges and on alternating traces on the 0.5 ms to 0.2 μs /DIV ranges.
 - CH2: Displays Channel 2 only.
13. **Ground terminal** — Provides a chassis ground that is connected to the 3-wire AC power cord.
14. **CH2 (Y) connector** — BNC connector connects the input signal to channel 2.
15. **POSITION/PULL INVert** — Positions the CH2 display vertically. In any X-Y mode, this control positions the CH2 Y-axis. When it is pulled out, the CH2 display is inverted.
16. **HOLDOFF** — Adjusts the time between sweeps, and is used when the time base triggering must be delayed to display complex waveforms (e.g. repetitive complex pulses). When you turn this control clockwise, from full counterclockwise (NORM), the holdoff time is continuously variable from no delay to 5 times normal sweep time. Operates only on ranges from 0.2 μs /DIV to 1 ms/DIV.

17. EXT IN — A BNC connector for external trigger signals. In the X-Y mode, with the TRIGGER SOURCE switch at EXT, the signal applied to this connector controls the X-axis of CH1 and/or CH2.
18. LEVEL — Selects the starting point voltage on the trigger source waveform at which the sweep is triggered. Turn the control fully counterclockwise to FIX (NORM) for a fixed level (0 volts).
19. SOURCE — Selects the triggering source signal as follows:
 - CH1: CH1 signal for triggering.
 - CH2: CH2 signal for triggering.
 - LINE: AC line-frequency voltage for triggering.
 - EXT: The signal applied to the EXT IN connector for triggering.
20. COUPLING — Selects the triggering mode as follows:
 - AC: Trigger signals are capacitively coupled to the trigger circuitry. Signals below 10 Hz are attenuated.
 - HF REJ: Attenuates triggering signals above 50 kHz.
 - TV: For observing TV signals.
 - DC: All trigger signals are directly coupled to the trigger circuitry.
21. SLOPE — Selects the triggering point on the positive or negative portions of the trigger signal.
22. SEC/DIV — Selects calibrated sweep rates from 0.5 s/DIV to 0.2 μ s/DIV in 1-2-5 sequence (20 ranges). At X-Y (fully counterclockwise), operation is for the X-Y mode. The alternate or chop and TV-V or TV-H operations are automatically selected by the switch.
23. SWEEP MODE selector —
 - AUTO: For normal triggering. Sweep free-runs in the absence of an adequate triggering signal.
 - NORMAL: For normal triggering. No CRT display in the absence of a triggering signal.
 - SINGLE/RESET: Allows only one sweep until reset. Reset the circuit by pushing this switch. The READY lamp indicates when the circuit is ready to be triggered.
24. POSITION — Positions the CH1 and/or CH2 trace horizontally.
25. VARIABLE/PULL X10 MAG — Provides continuously variable sweep rates to approximately 2.5 times the calibrated setting. At the CAL position, the sweep rate is set by the SEC/DIV switch. When you pull this VARIABLE switch out, the sweep speed is expanded 10 times.
26. Z AXIS INPUT connector — A BNC input connector for intensity modulation of the CRT trace.
27. OUTPUT connector — This BNC output connector provides the signal from the CH1 vertical preamplifier.
28. Fuseholder — Holds the AC line fuse. The rating is given in the nearby table.
29. AC INPUT socket — Receptacle for the 3-wire AC power cord.

PRELIMINARY OPERATION

1. Control settings:
 - A. POWER switch to OFF.
 - B. All three POSITION controls to mid-range.
 - C. INTENSITY control to midrange.
 - D. Push the sweep VARIABLE knob (25) for normal conditions.
 - E. Push the AUTO button of SWEEP MODE (23).
 - F. VARIABLE VOLTS/DIV (11) pushed in.
 - G. CH1 switch pushed in.
 - H. Other controls may be at any position.
 - I. Check the AC line voltage and plug installation on the rear panel.
2. Connect the AC line cord between the AC INPUT socket and an AC outlet.
3. Set the POWER Switch to ON. After about 20 seconds, a trace line will appear on the screen. If it does not appear, adjust the INTENSITY control to increase brightness to suit your lighting conditions.
4. Adjust the FOCUS and INTENSITY controls for a clear trace line.
5. Readjust the vertical and horizontal POSITION controls to obtain the desired location.
6. Connect a 10:1 probe to the input of CH1 and hook the tip to the CAL 2 V terminal.
7. Set the VOLTS/DIV switch of CH1 to 50 mV and the VARIABLE knob fully clockwise. Set the trigger SOURCE selector (19) to CH1. A square wave covering 4 divisions will then be displayed.
8. If the square wave has excessive rounding or overshoot, adjust the trimmer in the probe.
9. Remove the probe from the CAL terminal and repeat steps 6 through 8 for a second probe at CH2. The Oscilloscope is now ready for use.

TRIGGERING THE SWEEP

The horizontal (time base) circuitry can operate in three modes: AUTO, NORM, and SINGLE. In the AUTO mode, triggering of the sweep occurs even in the absence of an input signal. In the NORM mode, a display occurs only when conditions established by the triggering controls and switches are met (as described below). The SINGLE mode is identical to the NORM mode except that only one sweep can occur and the RESET button must be pushed after each sweep to enable the next sweep. The READY lamp indicates that the circuit is reset.

Triggered oscilloscopes include circuits to display stable waveforms. The synchronizing pulse for the triggering is derived from the vertical or a time-related signal. It is important that the triggering be synchronized with the vertical input. Five controls are provided in this Oscilloscope for this purpose:

1. SOURCE Selector (19):

- CH1: For internal triggering with the CH1 input signal.
- CH2: For internal triggering with the CH2 input signal.
- LINE: The AC line frequency is used for triggering.
- EXT: An external triggering signal connected to the EXT IN connector is used. This provides three benefits, depending on operating conditions:

- A. Triggering is not affected by variations of the vertical signals. For example, the triggering point normally changes for changes in the setting of the VOLTS/DIV switch since the synchronizing source voltage changes. Unless the external trigger voltage is changed, triggering is very stable and not dependent on the vertical control settings.
- B. You can delay the input signal by using the delay function of a pulse generator.
- C. A composite or modulated signal can be easily triggered.

2. COUPLING Selector (20): Selects the synchronizing circuit coupling. "AC" is for AC coupling and the DC component is blocked. At HF REJ, a low-pass filter is used to suppress any RF noise interference. The TV setting is for TV signal triggering; selection is made for TV-V or TV-H by the SEC/DIV switch.
3. SLOPE Selector (21): Selects the trigger slope, positive or negative, of the trigger signal. For TV synchronizing, the point is set to the rise or fall time of the pulse.
4. LEVEL Control (18): For stable triggering control over an adjustable range. The FIX (NORM) position selects a zero voltage offset to the trigger level.
5. HOLD-OFF Control (16): Improves triggering for the display of irregular repetitive waveforms. Adjust as required to delay retriggering the sweep.

X-Y DISPLAY OPERATION

For the most common X-Y applications, set the SEC/DIV switch to X-Y, the TRIGGER COUPLING switch to DC, the TRIGGER SOURCE switch to CH1, and PUSH the CH2 pushbutton of the VERT MODE switch. All CH1 functions operate as a horizontal (X-axis) amplifier with the horizontal position control, while CH2 functions as a vertical (Y-axis) amplifier. For X-Y operation with dual Y channels, set the TRIGGER SOURCE switch to EXT and connect the X-axis signal to the EXT IN BNC connector. Both CH1 and CH2 then display Y-axis signals.

VOLTAGE MEASUREMENTS

You can use either the CH1 or CH2 input of the Oscilloscope as a voltmeter to measure peak, peak-to-peak, DC voltages, or a specific portion of a complex waveform.

1. Set the VARIABLE control of the VOLTS/DIV to the CAL position. Next set the VOLTS/DIV switch for the trace amplitude to be used. Adjust the vertical POSITION control to set the reference level.
2. For DC or complex signals, first set the input switch to GND and then adjust the vertical POSITION control for a reference level. A positive voltage will deflect the trace upward and vice versa. For the voltage, multiply the vertical (division) deflection by the setting of the VOLTS/DIV switch. NOTE: When a 10:1 probe is used, the waveform display is only 1/10 of the actual voltage being measured.

DUAL TRACE DISPLAY

The MODE selector is set to DUAL. In this operating mode, procedures given above are the same.

SYNCHRONIZING TV SIGNALS

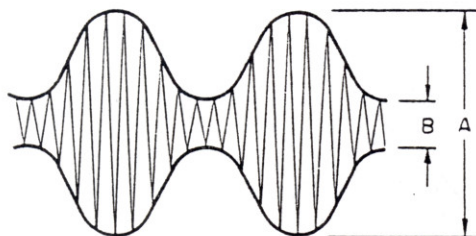
Set the Trigger COUPLING selector (20) to TV. TV frame and line triggering is automatically selected by the SEC/DIV switch. That is, frame is selected on the .5 s to the .1 ms positions, and line is selected from the 50 μ s to the .2 μ s positions.

ADDITION AND SUBTRACTION OPERATION

When the CH1 POSITION knob is pulled (ADD mode), the display will be the algebraically added waveforms of CH1 and CH2. The subtracted waveform is displayed when the CH2 vertical POSITION knob is pulled for INVERT.

AM MODULATION MEASUREMENT

There are several methods of measuring AM modulation, but here the envelope method is shown. This method is applicable only if the carrier frequency is within the bandwidth of this instrument. Figure 4 shows the display of a modulated wave.



$$\text{Mod., \%} = \frac{A - B}{A + B} \times 100$$

Figure 4

DUAL TRACE APPLICATIONS

For this application, set the VERT MODE selector to DUAL. Signals at Channel 1 and 2 will be displayed simultaneously. The two signals can then be compared with respect to level, waveform, phase, etc.

COMPARISON OF LEVELS

An example of interconnections is shown in Figure 5 for the output/input level comparison of an amplifier.

Set the displays of CH1 and CH2 to be superimposed using the POSITION controls. The gain in the amplifier will be the difference in settings of the respective VOLTS/DIV switches. When the signals cannot be matched, even if the VARIABLE controls are adjusted, the difference is due to distortion in the amplifier. In this case, set the VERT MODE selector to ADD and pull the POSITION knob of CH2 to view only the distortion; the trace will be a straight line when distortion is absent.

CHECKING STEREO SYSTEMS

Stereo audio systems have two symmetrical amplifier circuits. Using the dual trace feature, it is possible to compare and check the operation in each circuit. Location of any defective portion is thus simplified.

SERVICING TV SETS

In this application, a triggered oscilloscope is indispensable. This instrument can synchronize to either the TV-V (Frame) or TV-H (Line) of the video signal to display the blanking pedestal, VITS, or vertical/horizontal synchronizing pulses.

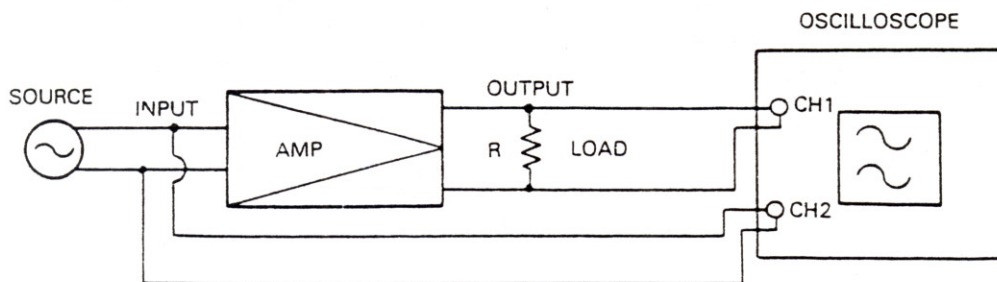


Figure 5

COMPOSITE VIDEO ANALYSIS

The most important waveforms in TV servicing are the composite signals consisting of the video, blanking pedestal and sync pulses. Figures 6 and 7 show composite signals synchronized with horizontal synchronizing and vertical blanking pulses.

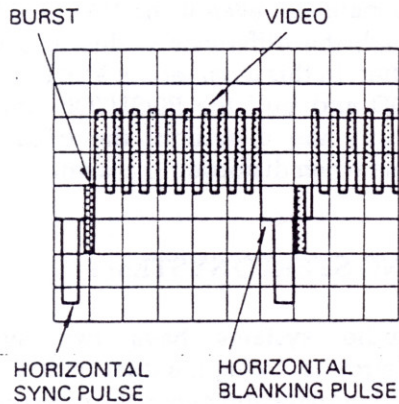


Figure 6

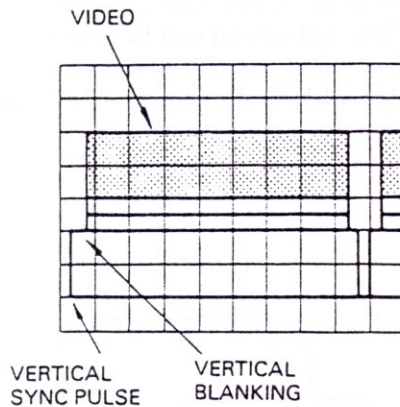


Figure 7

FREQUENCY MEASUREMENT WITH X-Y METHOD

Set the SEC/DIV switch and trigger switches for X-Y operation. Connect a standard frequency signal to CH1 and the unknown signal to CH2. Then CH1 is the X-axis and CH2 the Y-axis. The display will be the lissajous figure, examples of which are shown in Figure 8.

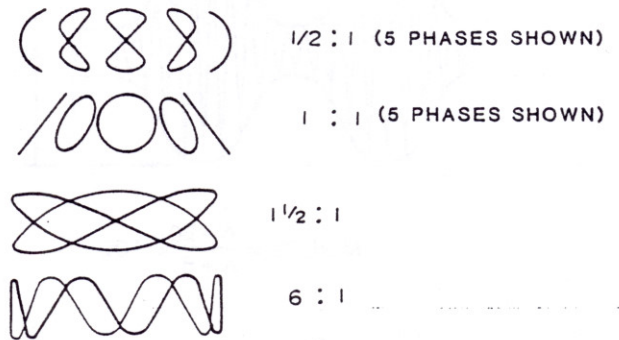


Figure 8

PHASE MEASUREMENT

Using the X-Y function, connect the two input signals to the CH1 and CH2 connectors. The phase is calculated with the relation shown in Figure 9.

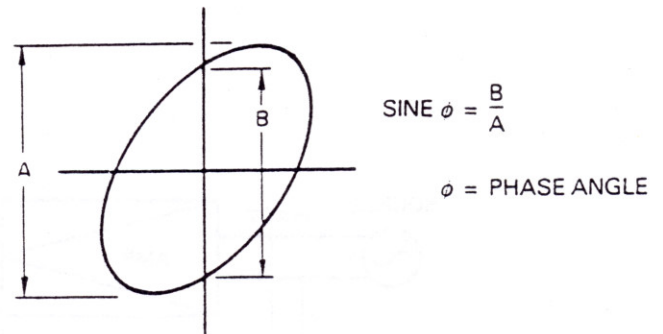


Figure 9

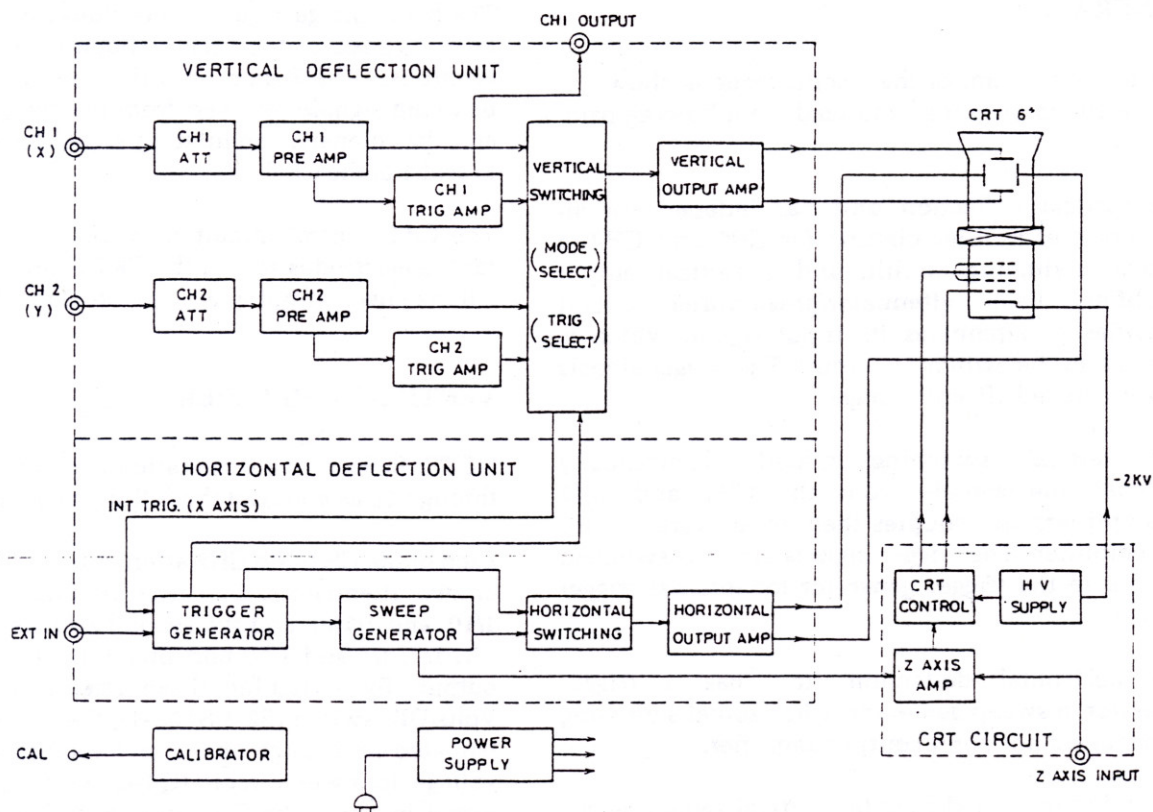


Figure 10 Block Diagram

CIRCUIT DESCRIPTION

GENERAL

The block diagram of the Oscilloscope is shown in Figure 10. Refer to it as you read the following paragraphs.

The vertical deflection unit has independent attenuator/preamplifier circuits for CH1 and CH2, a vertical switching circuit, and a vertical output amplifier. Each attenuator/preamplifier circuit amplifies or attenuates its input signal, which is then fed to the switching circuit. The trigger signals also are picked off at this stage.

The vertical switching circuit electronically switches the signals from the CH1 and CH2 preamplifiers and couples them to the vertical output amplifier. The trigger signals are also switched and fed to the trigger generator for internal trigger signals.

The horizontal deflection unit has a trigger generator, a sweep generator, a horizontal switching circuit and a horizontal output amplifier.

The switching signal from the vertical switching circuit or EXT IN connector is amplified and shaped to a trigger pulse signal in the trigger generator.

The sweep generator is driven by the pulses from the trigger generator and produces a sawtooth signal in the triggered sweep mode.

The horizontal switching circuit electronically switches the sawtooth signals from the sweep generator in the normal mode and from the trigger signals (internal, line, and external) in the X-Y mode. These signals are then coupled to the horizontal output amplifier to provide the horizontal deflection.

The CRT circuit is comprised of a high voltage regulator to accelerate the electron beam, a Z-axis amplifier to blank out the return traces, and a CRT control circuit to adjust the trace.

The high voltage regulator provides a 2.0 kV voltage to be applied to the CRT cathode to accelerate the electrons. The Z-axis amplifier amplifies the unblanking signals received from the sweep generator and the intensity modulating signal for application to grid 1 of the CRT.

The CRT control circuit provides various voltages for the electrodes so that the CRT is properly biased. All the power supplies are regulated for stability.

VERTICAL AMPLIFIER

NOTE: Refer to the schematic diagrams on Pages 25 through 30 as you read the following paragraphs.

Each of the CH1 and CH2 attenuator circuits consists of two attenuators. The first attenuator is for 1/1, 1/10, and 1/100, and the second attenuator provides 1/1, 1/2, 1/4 and 1/10 portions of the first attenuator output. By switching these attenuators with the Volts/DIV switch (S2-1/S102-1), the signal can be attenuated in a range of 1/1 to 1/1000 in 10 steps. A voltage follower circuit (Q1-Q4/Q101-Q104) is inserted between the first and second attenuators to obtain a high input impedance. The second attenuator provides a low-impedance output signal to be fed to the first differential cascade amplifier (IC2/IC102).

The first differential cascade amplifier is comprised of an emitter-connected differential current amplifier and a current-to-voltage converter (IC2 or IC102). This amplifier also has the Variable circuit (VR39/VR139) for continuously-variable adjustment of the deflection factor between the steps of the Volts/DIV switch, and the X5MAG switch (S2-2/S102-2) for magnifying the vertical sensitivity by 5 times.

The second differential cascade amplifier (Q5,6,7,8/Q105, 106, 107 – 110) amplifies the output from the first amplifiers to a level that is sufficient to drive the vertical switching circuit. The Q109, Q110 portion of the amplifier is used with the INV switch to invert the polarity of the CH2 signal.

The output signal of the second amplifier is fed directly in the form of a current signal to the diode gate network of the vertical switching circuit. The current signal for vertical positioning of the trace is added to the current signal in the second amplifier, and is controlled by VR54/VR154 in the positioning circuit.

A signal within each of the second amplifiers is amplified by Q10 or Q111, and fed to the vertical switching circuit as an internal trigger signal. At CH1, a signal is also fed to the CH1 Output terminal through impedance converter Q11.

The vertical switching circuit determines whether the CH1 or the CH2 preamplifier signal, or both, will be connected to the vertical output amplifier circuit. This circuit is comprised of diode gate circuits, which electronically switch the vertical signals of CH1 and CH2, and a switching buffer (Q201, 202) which provides the switched signals to the vertical output amplifier. The switching buffer output is routed through a delay line (DL1) which allows the sweep waveform to start before the vertical signal is applied to the CRT.

Drive amplifier Q301/Q302 in the vertical output amplifier is a feedback amplifier, with a low output impedance for driving the final amplifier. The final amplifier circuit provides the final amplification for the signal and applies it to the vertical deflection plates of the CRT. Transistors Q303–Q306 supply the necessary current for driving the final stage transistors, Q307–Q310. The signal is voltage-amplified in this stage and fed to the CRT for vertical deflection.

HORIZONTAL/TIME BASE

The trigger generator is comprised of a pulse generator circuit which produces a trigger pulse signal for driving the sweep generator, and an AUTO circuit which produces a free-running signal for automatic sweep operation when no trigger is applied.

The trigger pulse generator circuit includes a source switch (S401), a coupling switch (S402), an impedance converter (Q403), a level comparator (Q404, Q405), a TV synchronization separator (Q410, Q411), and a Schmitt trigger circuit (IC401).

The source switch selects the internal trigger signal fed from Q401, the line trigger signal from R1025, or an external signal from P405. The selected signal is fed to the coupling switch.

The coupling switch selects the mode of trigger coupling. In the AC, HF REJ and TV modes, the DC component of the trigger signal is blocked by coupling capacitor C409 and the frequency components below 10 Hz are attenuated. In the HF REJ trigger coupling mode, the high frequency components of the trigger signal above about 50 kHz are attenuated, while the lower frequency components (between about 10 Hz and 50 kHz) are passed without attenuation. In the TV mode, the sync signal is separated from the video signal by the TV synchronization separator. The DC mode of trigger coupling passes all signals from DC to 25 MHz and above.

Impedance converter Q403 is an FET source follower. It provides a high input impedance for the trigger signal and operates as a buffer between the trigger generator circuit and the trigger signal sources. The output signal from the impedance converter is fed to the level comparator circuit.

The level comparator (Q404, Q405) is a differential amplifier which selects the rising edge (or the falling edge) of the impedance converter output signal. The comparator highly amplifies any voltage difference between the impedance converter output and the reference level from the Level control VR441/S441. At the Fix position of the Level control, the trigger point is locked at the center portion of the trigger range by feeding the output of the level fixing circuit (Q406–Q409) back to Q405.

The slope of the trigger signal is selected by Slope switch S403.

The output signal of the level comparator is fed to the buffer amplifier (Q410-413) and amplified sufficiently to drive Schmitt trigger circuit IC401. The output of IC401 drives the sweep generator and the auto circuit (Q601, Q602) which converts the high speed pulse signal of the Schmitt trigger circuit into a DC signal for operating the sweep generator in the Auto mode.

The sweep generator includes a sweep gate circuit (IC601-1/2), a sweep start comparator (Q603, Q604), a sweep enable circuit (IC601-1/2) a hold off circuit (Q613), a sawtooth sweep generator and a sweep length circuit (Q616). The sawtooth sweep generator is comprised of a gate transistor amplifier, a Miller integrator, an integration time constant switching circuit and a SEC/DIV switch which controls the switching circuit.

The sweep generator produces the sawtooth voltage that is amplified by the horizontal amplifier to provide horizontal deflection on the CRT. This circuit also produces the gate waveform used by the Z-axis circuit to unblank the CRT during the sweep time.

Gate transistor amplifier Q603 alternately resets the two selectable sweep ramp capacitors (C606/607 or C606/607/608) through Q605 and Q606 or allows the capacitors to charge. A constant current from Q608 generates a bias (zero) current through R618, Q612, D621, D622, and R621. A current selected by the SEC/DIV switch is generated by the IC603/Q611 circuit and charges the sweep capacitors also through the same bias circuit. The current difference produces a ramp at R621.

The sawtooth voltage ramp is fed to the horizontal output amplifier through switching circuit IC602, which selects the internal or external signals.

The horizontal output amplifier consists of a drive amplifier and an output amplifier. The drive amplifier (Q801-Q804) converts the single-ended signal from the switching circuit into a push-pull signal for driving the output amplifier. The gain of this amplifier can be multiplied by a factor of 10 for the $\times 10$ MAG operation.

The output amplifier (Q805-Q812) which consists of two single-ended feedback amplifiers, amplifies the signal at its input to produce the output to drive the horizontal deflection plates of the CRT. The signal current amplified by Q805 and Q806 is converted into a voltage signal by Q807-Q812 to obtain a sufficiently high level and a low output impedance. By means of negative feedback resistors (R817, R818), stable gain and a wide flat frequency response are achieved.

CALIBRATOR

The calibrator circuit provides a square-wave output signal with an accurate voltage of 2 V p-p ($\pm 2\%$) which is used to calibrate the vertical deflection factor. The calibration signal is produced by generating a signal with the multivibrator (IC4001-1/4, 2/4), shaping the waveform with the Schmitt circuit (IC4001-3/4, 4/4), and dividing the voltage signal with resistors R4009-4012.

CRT CONTROL

The CRT control circuit provides the voltage levels and control circuits necessary for operation of the CRT. Q2001 and its associated circuitry compose the high-frequency oscillator which produces the drive for high voltage transformer T2001. The high voltage output is rectified by D2010 and D2011, and converted into -2000 volts DC. This high voltage is supplied to the CRT cathode as an acceleration voltage, and is stabilized by the regulator circuit (IC2001).

POWER SUPPLY

The low voltage power supply circuit supplies the operating power for the Oscilloscope from four regulated power supplies (+160 V, +5 V, +12 V, -12 V) and one unregulated power supply (+16 V). The output voltages of the two windings of the power transformer are rectified and then regulated.

MAINTENANCE & ADJUSTMENTS

GENERAL MAINTENANCE

Preventive Maintenance — Clean and recalibrate the Oscilloscope on a regular basis to keep the instrument looking nice and working well.

Cleaning — Remove any dirt, dust and grime whenever they become noticeable. You can remove dirt from the outside covers with a soft cloth moistened with a diluted household cleaning solution.

Recalibration — Recalibrate the Oscilloscope at regular intervals; after 1000 hours of operation, for example, or twice a year if used daily.

Servicing — Should the Oscilloscope ever become inoperative or damaged, refer servicing to a qualified repair facility.

ADJUSTMENT AND CALIBRATION

WARNING: Be careful when you are calibrating the Oscilloscope; dangerous high voltage is present in several areas.

NOTE: Some controls are factory preset and are not included in this calibration procedure. These need no adjustment unless you replace those parts. In this event, contact the Heath Customer Service department.

Power Supply Adjustments (Figure 11)

1. **+12V adjustment** — Adjust VR1006 for $+12 \pm 0.05$ V between pin 2 on connector P1007 and ground. Adjust this voltage very carefully, as it provides a reference for other supplies.
2. **-12V check** — Check pin 3 on P1007 for proper voltage, -12 ± 0.2 V.
3. **+5V check** — Check pin 4 on P1007 for proper voltage, $+5V \pm 0.25$ V.
4. **+160V check** — Check pin 6 on P1007 for proper voltage, $+160V \pm 5$ V.
5. **-2000V check** — Check pin 3 on connector P2005 for $-2000V \pm 50$ V. Use a high input impedance voltmeter (10 M Ω or more) rated for high voltage measurements.

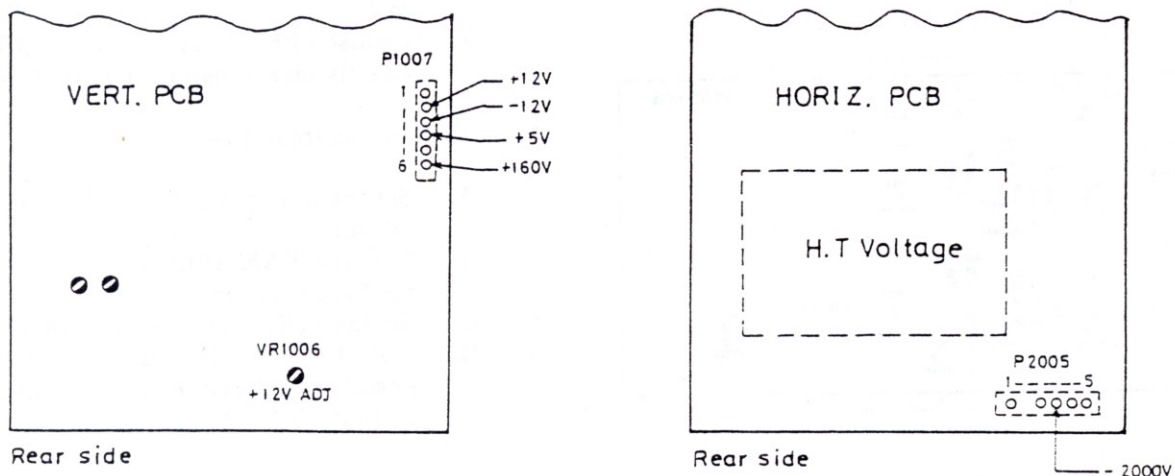


Figure 11
Check points of DC supply.

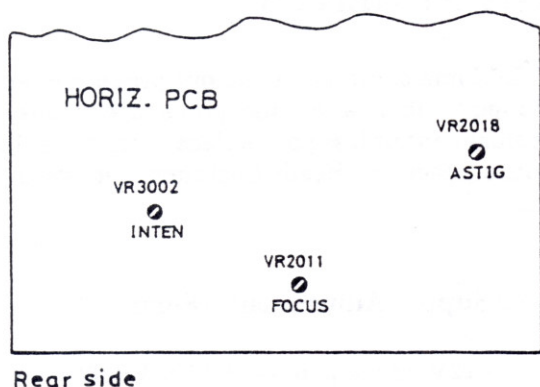


Figure 12

Location of adjusters for CRT circuit.

CRT Circuit Adjustments (Figure 12)

1. Intensity — Adjust VR3002 so that the trace line just dims with the front panel INTENSITY control at the 10 o'clock position.
2. Focus — Adjust VR2011 to obtain the best focus with the front panel FOCUS control at the 12 o'clock position.
3. Astigmatism — Adjust VR2018 so that the shape of the displayed beam spot (in the X-Y mode) becomes as circular and sharp as possible.

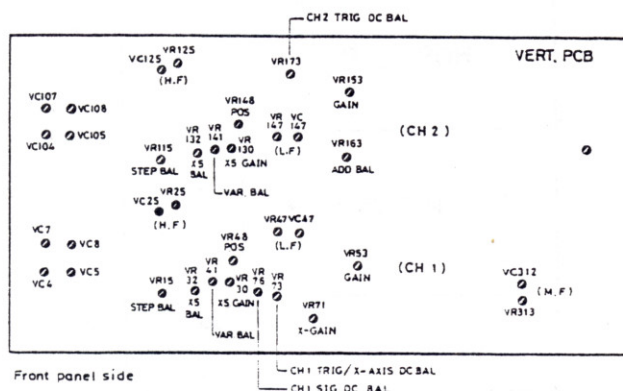


Figure 13

Locations of vertical circuit controls.

Vertical Axis Adjustments (Figure 13)

NOTE: Perform the following adjustments for CH1 as indicated and then repeat the steps for CH2.

1. Step balance — If the trace line shifts vertically when you switch between the most sensitive positions of the VOLTS/DIV switch (10), adjust VR15 (for CH1) or VR115 (for CH2) to obtain minimum shift.
2. $\times 5$ MAG balance — If the trace line shifts when you pull the VARIABLE knob (11) for $\times 5$ magnification, adjust VR32 (CH1) or VR132 (CH2) to obtain minimum shift.
3. Variable balance — If the trace line shifts when you turn the VARIABLE knob, adjust VR41 (CH1) or VR141 (CH2) for minimum shift.
4. TIME/CM switch — Set to 1 ms.
5. Sensitivity calibration — For this adjustment, you will need a 1 kHz square wave generator that has an output voltage that you can set with 1% accuracy or better.
 - A. Set the square wave generator for a 20 mV output and connect it to the CH1 or CH2 input terminal, as required, through a terminated 50 Ω BNC cable.
 - B. Set the VARIABLE knob to the CAL position and set the VOLT/DIV switch to 5 mV.
 - C. Adjust VR53 (CH1) or VR153 (CH2) for exactly four divisions of amplitude.
6. $\times 5$ MAG calibration —
 - A. Set the square wave generator for a 5 mV output.
 - B. Pull the VARIABLE knob and set it to the CAL position.
 - C. Set the VOLTS/DIV switch to 5 mV.
 - D. Adjust VR30 (CH1) or VR130 (CH2) for exactly five divisions of amplitude.
 - E. Push the VARIABLE knob to X1.

7. ADD balance.

- A. Set the AC-GND-DC switches (8) to GND and set the trace lines of CH1 and CH2 respectively to the center of the screen.
- B. Change the VERT MODE switch (12) to DUAL, pull the CH1 POSITION knob to ADD, and adjust VR163 to position the trace at the center of the screen.

8. Vertical transient response — For this adjustment, you will need a high quality square wave with a rise time of 1.0 ns or faster.

A. Middle frequency range

1. Set the VOLTS/DIV switch to 5 mV and the SEC/DIV to 0.2 μ s.
2. Apply a square wave of 1 MHz to the CH1 or CH2 input and adjust its level for 5 divisions of amplitude.
3. Adjust VR313 and VC312 for the best flat-top display at about the 20 nanosecond point from the rising edge.

B. High frequency range. This adjustment is to further sharpen the display by reducing the ringing at the leading edge of the waveform.

1. Pull the horizontal VARIABLE knob to $\times 10$ magnification and display the edge of the pulse waveform which has been adjusted in step 7 above.
2. Adjust VR25/VC25 (CH1) or VR125/VC125 (CH2) for minimum distortion.

C. Low frequency range.

1. Push the VARIABLE knob, and apply a 100 kHz square wave to the CH1 or CH2 input.
2. Adjust VR47/VC47 (CH1) or VR147/VC147 (CH2) to reduce the sag in the waveform 10 to 70 nanoseconds from the rising edge.

9. Input Attenuator: This procedure is for compensation and input capacitance adjustment of the attenuators. A square wave generator is required that has a high quality waveform with a rise time of 1 μ s or faster and without sag or overshoot.

- A. Apply the signal to the appropriate input connector. First set the VOLTS/DIV switch to the .1 position and then to the 1 position, and display a Waveform with an amplitude of six divisions.
- B. Adjust the following compensation capacitors to obtain an ideal waveform display.

<u>RANGE</u>	<u>ADJUST CAPACITOR</u>
0.1V (1/10)	VC5 (CH1) or VC105 (CH2)
1V (1/100)	VC8 (CH1) or VC108 (CH2)

- C. Connect a low range capacitance meter to the CH1 or CH2 input and adjust the following capacitors so the input capacitance of each range is 25 ± 2 pF.

<u>RANGE</u>	<u>ADJUST CAPACITOR</u>
0.1V (1/10)	VC4 (CH1) or VC104 (CH2)
1V (1/100)	VC7 (CH1) or VC107 (CH2)

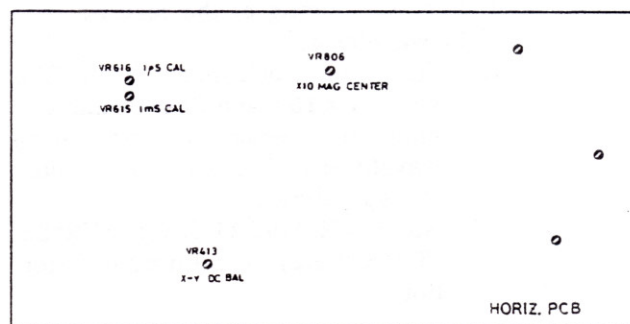
10. CH1 trigger offset (X-axis DC balance).

- A. Apply a sinusoidal signal of 1 kHz to the CH1 input and set the AC-GND-DC switch to AC.
- B. Set VERT MODE to CH1, set SOURCE (19) to CH1 and display the signal with an amplitude of 6 divisions.
- C. Set COUPLING (20) to AC and set the trigger point to the center of the amplitude of the waveform by adjusting the LEVEL knob (18).
- D. Change COUPLING to DC and adjust VR73 to position the trigger point to the same point on the wave form.

11. CH1 OUTPUT DC offset.
 - A. Set AC-GND-DC to GND and VOLTS/DIV to 5mV.
 - B. Position the trace at the center horizontal graticule line with the CH1 POSITION control.
 - C. Terminate CH1 OUTPUT (rear panel) with a 50 Ω resistor.
 - D. Adjust VR76 so that the output of CH1 OUTPUT is 0 VDC.
12. CH2 trigger offset: The procedure is similar to step 9 above except that the settings are for CH2. Adjust VR173 to position the trigger point at the center of the waveform.
13. X-axis GAIN.
 - A. Set VOLTS/DIV to 5 mV, SEC/DIV to X-Y, and VERT MODE to CH2.
 - B. Apply a signal of 20 mVp-p to the CH1 input.
 - C. Adjust VR71 so that the trace length is 4 divisions.
2. Time base calibration. For calibrating the sweep time of the SEC/DIV switch, use accurate time intervals of 1 ms and 1 μ s.
 - A. Apply a time marker signal of 1 msec to the CH1 input and set SEC/DIV to 1 ms.
 - B. Adjust VR615 so that the displayed waveform aligns with each vertical graticule line.
 - C. Change the time interval of the input signal to 1 μ s and also set the SEC/DIV to 1 μ s.
 - D. Adjust VR616 so that the displayed waveform aligns with each vertical graticule line.
3. $\times 10$ MAG center adjustment.
 - A. Apply a time marker signal of 1 ms and set SEC/DIV to 1 ms.
 - B. Pull the time base VARIABLE knob and adjust VR806 so that the center waveform aligns with a center vertical graticule line.

Horizontal Axis Adjustments (Figure 14)

1. X-Y DC balance adjustment.
 - A. Set the SEC/DIV switch to X-Y, the horizontal POSITION switch (24) to mid-range, and AC-GND-DC of CH1 to GND.
 - B. Adjust VR413 to position the beam spot at the center of the screen.



Front Panel side

Figure 14

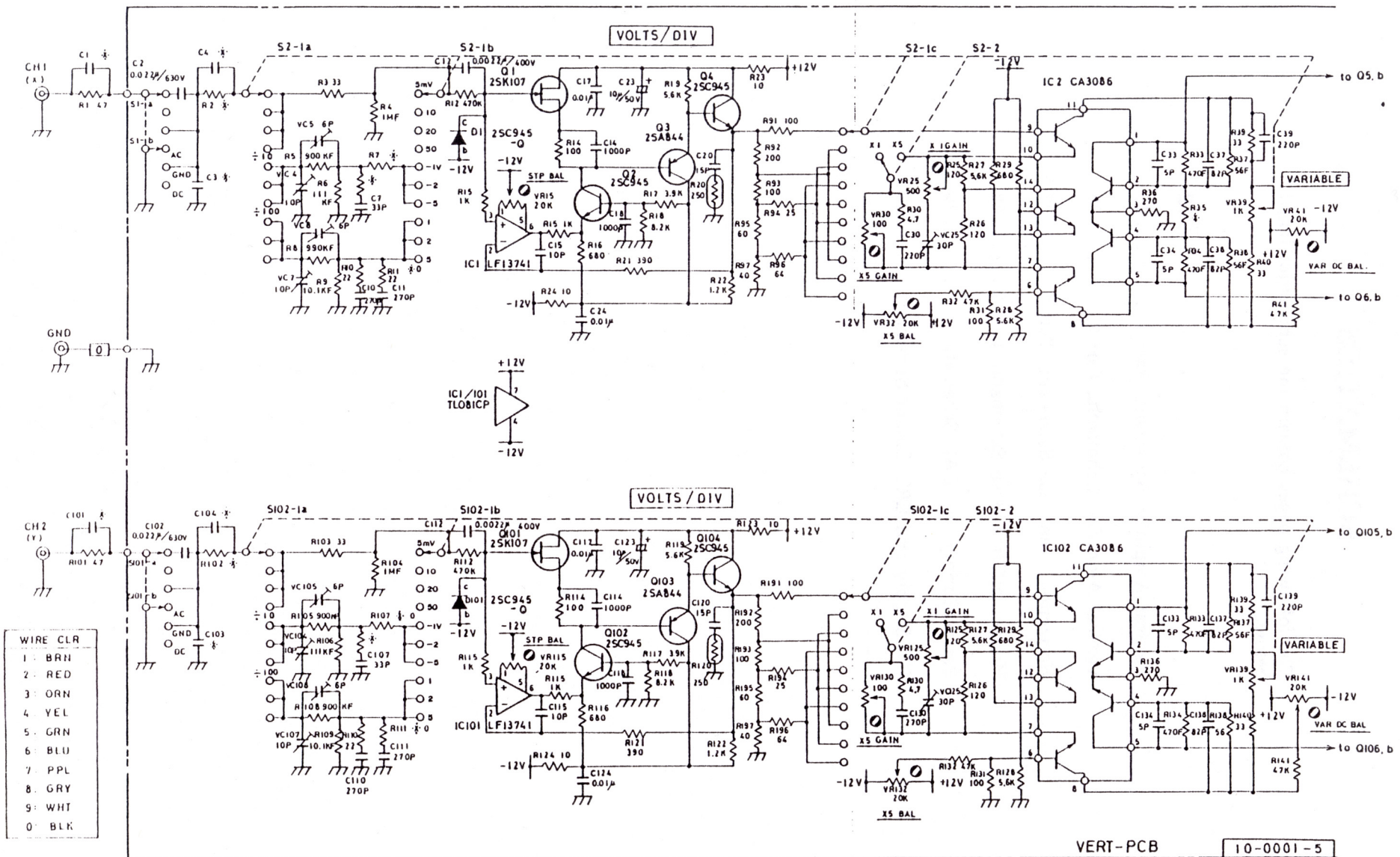
Locations of horizontal axis controls.

SCHEMATICS

The following pages contain the schematics listed below.

	<u>Page</u>
Vertical Amplifier Schematic, Part 1	25
Vertical Amplifier Schematic, Part 2	26
Horizontal/Time Base Schematic, Part 1	27
Horizontal/Time Base Schematic, Part 2	28
Power Supply and CAL Schematic	29
HV Supply and CRT Circuit Schematic	30

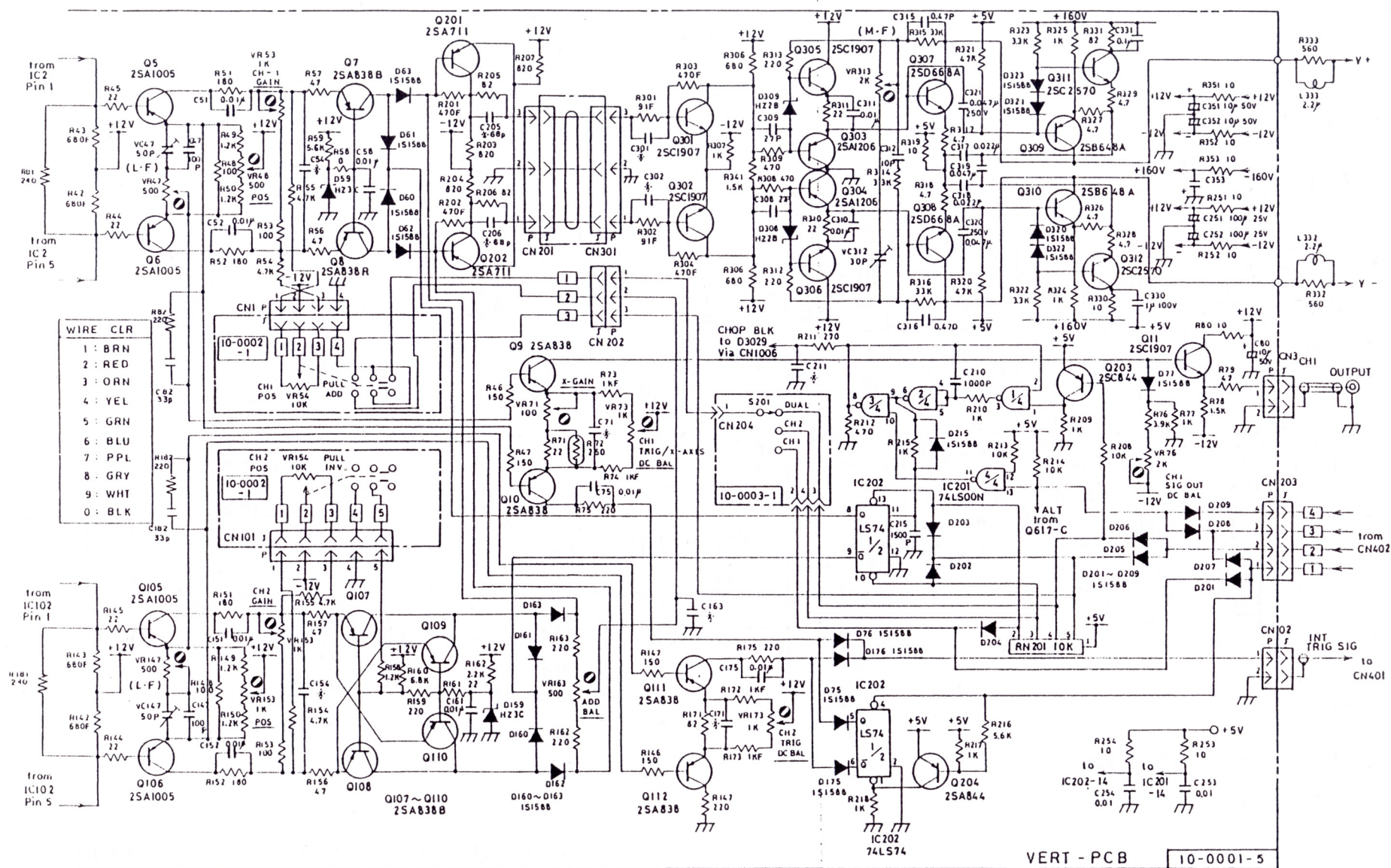
VERTICAL AMPLIFIER SCHEMATIC, PART 1



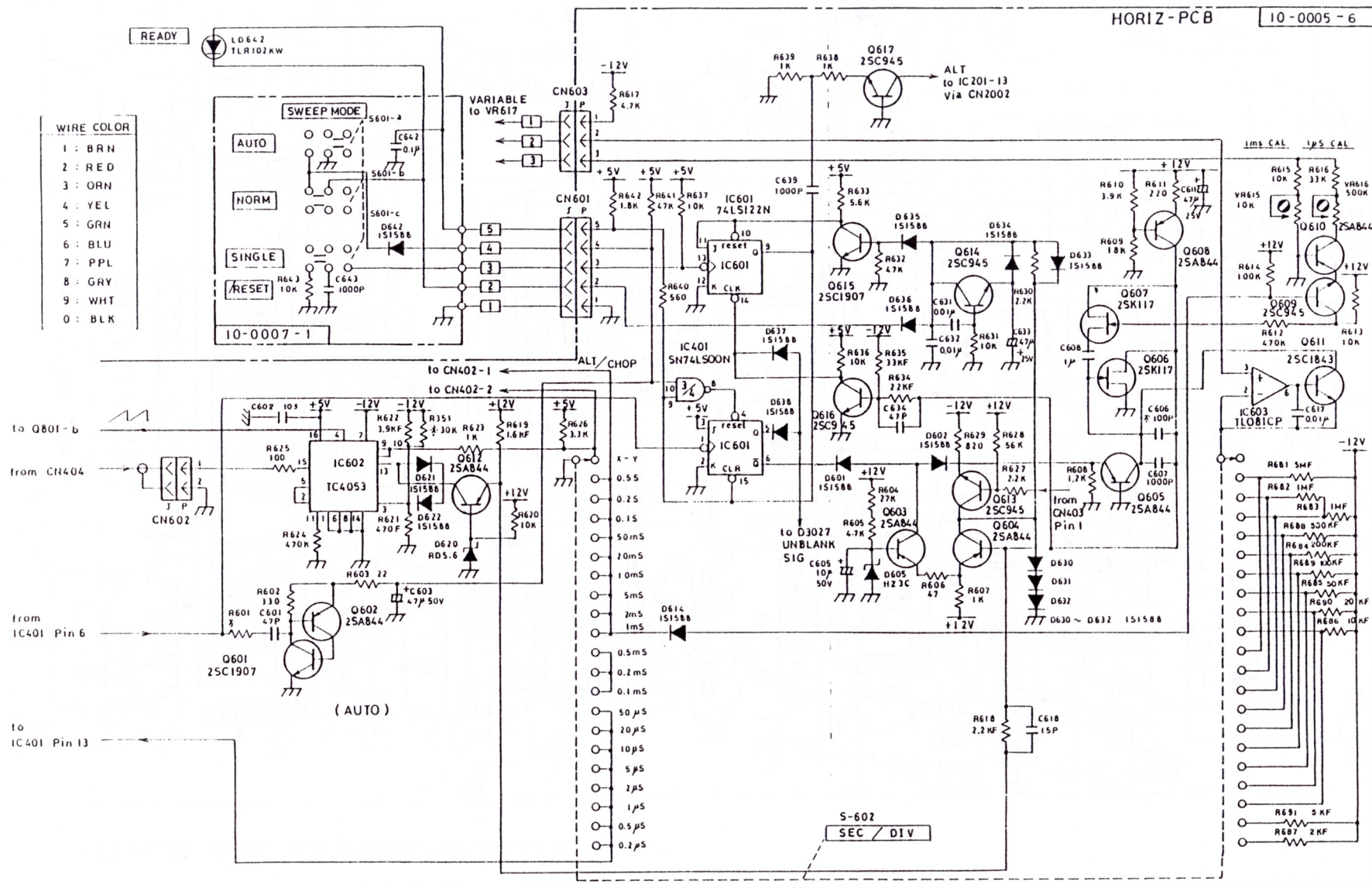
⌘ This symbol indicates a factory-installed part which may have a different value from the one shown.

"F" indicates a 1% tolerance resistor.

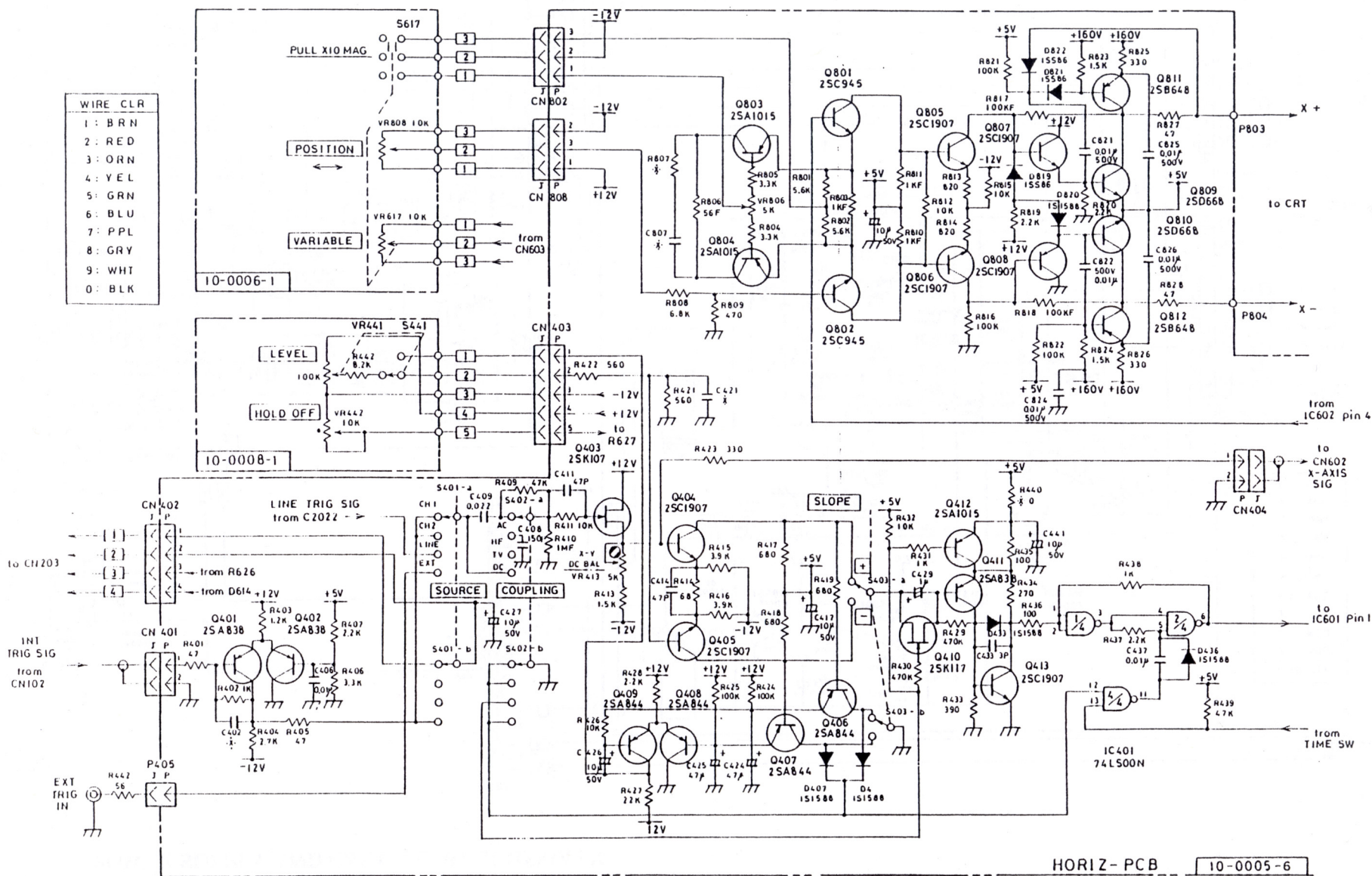
VERTICAL AMPLIFIER SCHEMATIC, PART 2



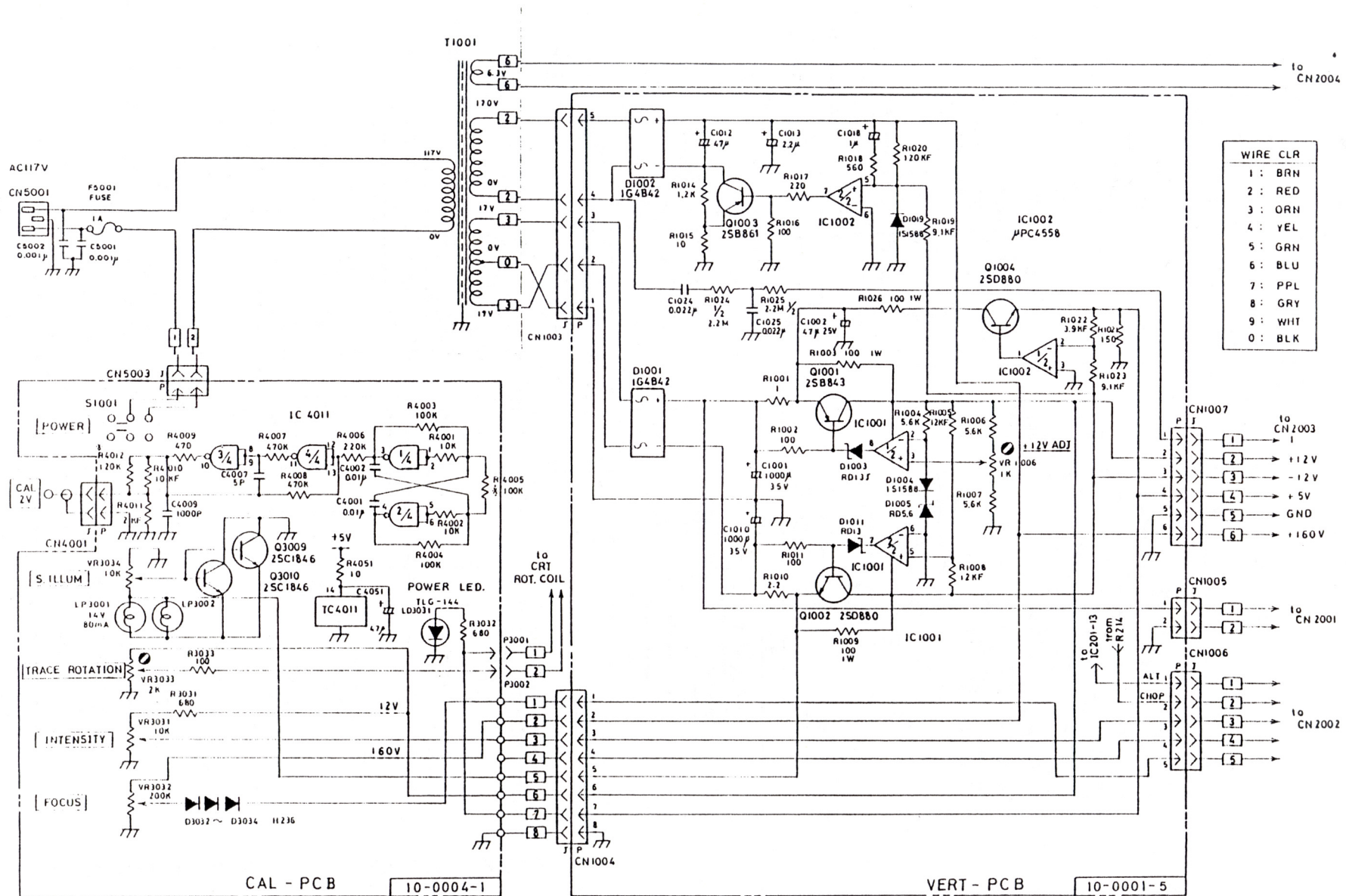
HORIZONTAL/TIME BASE SCHEMATIC, PART 1



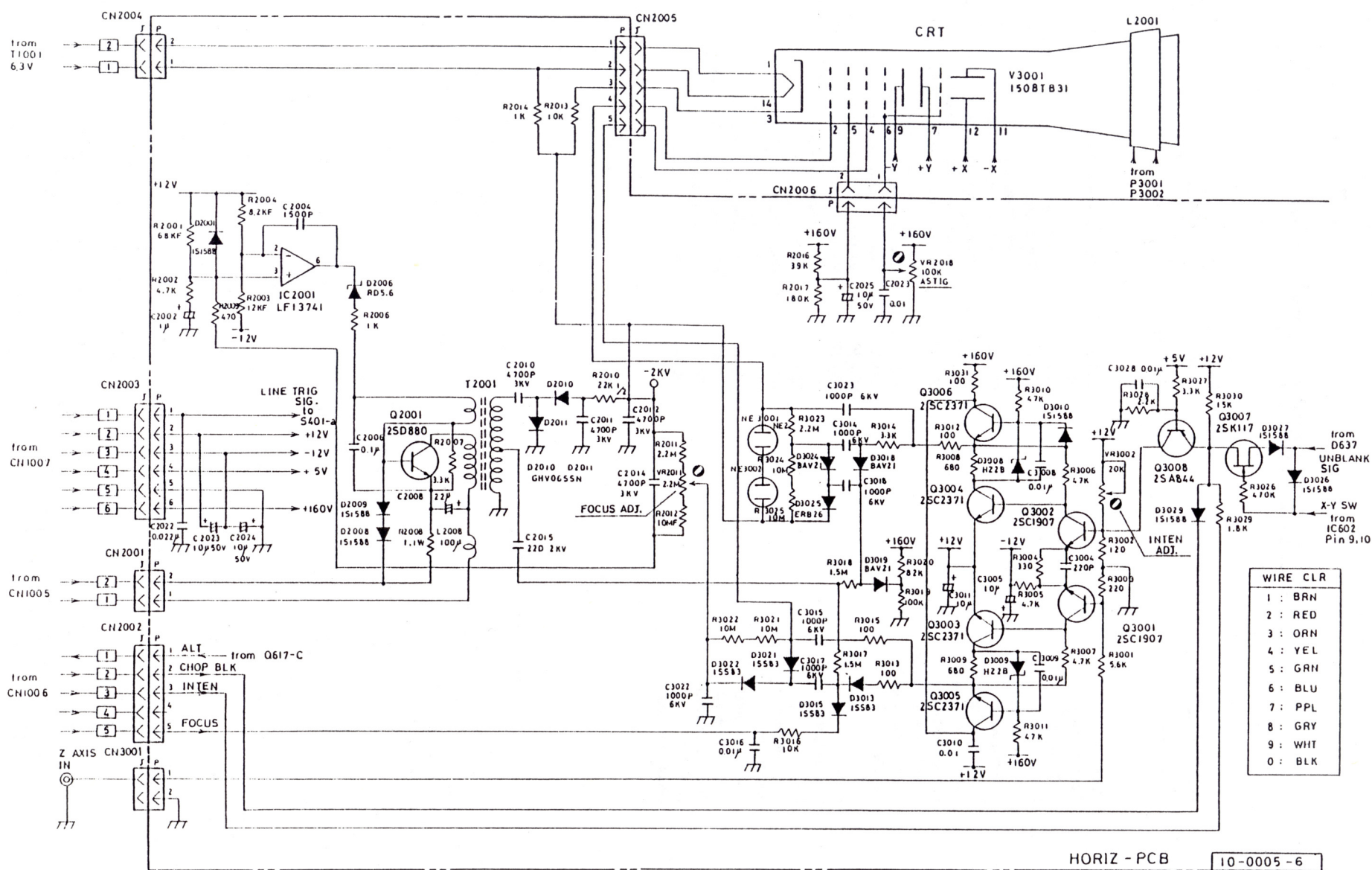
HORIZONTAL/TIME BASE SCHEMATIC, PART 2



POWER SUPPLY AND CAL CIRCUIT SCHEMATIC



HV SUPPLY AND CRT CIRCUIT SCHEMATIC



REPLACEMENT PARTS LIST

<u>HEATH</u> <u>Part No.</u>	<u>DESCRIPTION</u>	<u>HEATH</u> <u>Part No.</u>	<u>DESCRIPTION</u>
930-1	Case top	930-24	Calibrator output pin
930-2	Case bottom	930-25	CRT
930-116	Rear panel	930-26	CRT socket
930-117	Front panel	930-27	Trace rotation coil
930-5	Side escutcheon	930-120	Power transformer
930-6	CRT bracket	930-121	Horizontal/time base/HV supply board assembly
930-7	Frame (top right)	930-122	Vertical amplifier/power supply board assembly
930-8	Frame (top center)	930-123	Cal/CRT control circuit board
930-9	Frame (bottom right)	930-32	Horiz position & horiz variable assembly
930-10	Frame (bottom center)	930-33	Trigger level assembly
930-11	Frame (bottom left)	930-34	Vertical position assembly
930-12	Handle	930-35	Sweep mode assembly
930-13	Bail	930-36	Vertical mode assembly
930-14	Bezel	930-37	Knob (Scale Illum, Horiz Pos, Horiz Var, Vert Pos, Intensity, Focus)
930-15	Molded foot	930-38	Knob (Trigger Level)
930-16	Foot	930-39	Knob (Hold Off)
930-17	Graticule filter	930-40	Knob (Vertical Variable)
930-118	Fuseholder	930-41	Knob (Vertical Attenuator)
930-119	Fuse (1-ampere)	930-42	Knob (Horizontal Time Base)
930-20	Voltage selector	930-43	Knob (slide switch)
930-21	Power connector	930-44	Knob (pushbutton)
930-22	Line cord		
930-23	Ground terminal		

CUSTOMER SERVICE INFORMATION

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath/Zenith Computers and Electronics Centers. Be certain to include the HEATH part number.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH/ZENITH COMPUTERS AND ELECTRONICS CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath/Zenith Computers and Electronics Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath/Zenith Computers and Electronics Center.

TECHNICAL CONSULTATION

Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heath/Zenith Computers and Electronics Centers are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your product. (Units that have been modified cannot be accepted for repair.)

If it is convenient, personally deliver your unit to a Heath/Zenith Computers and Electronics Center. To establish warranty, supply a copy of the invoice or sales slip.

If you prefer to ship your unit to the factory, attach a letter containing the following information directly to the product:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the unit.
- A brief description of the difficulty.
- Authorization to return your unit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. Place the equipment in a strong carton with at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions. If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Post, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information (616) 982-3411
 Credit (616) 982-3561
 Replacement Parts (616) 982-3571

Technical Assistance Phone Numbers

8:00 A.M. to 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only

R/C, Audio, and Electronic Organs (616) 982-3310
 Amateur Radio (616) 982-3296
 Test Equipment, Weather Instruments and
 Home Clocks (616) 982-3315
 Television (616) 982-3307
 Aircraft, Marine, Security, Scanners, Automotive,
 Appliances and General Products (616) 982-3496
 Computers — Hardware (616) 982-3309
 Computers — Software:
 Operating Systems, Languages, Utilities (616) 982-3860
 Applications Programs (616) 982-3884
 Heath Craft Wood Works (616) 982-3423

YOUR HEATH ASSEMBLED PRODUCT ONE-YEAR LIMITED WARRANTY

Welcome to the Heath family. We believe you will be pleased with the performance of your new Heath assembled product. Please read this consumer protection plan carefully. It is a "LIMITED WARRANTY" as defined in the U.S. Consumer Product Warranty and Federal Trade Commission Improvement Act. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

HEATH'S RESPONSIBILITY

PARTS — Replacement for defective parts will be supplied free for one year from date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. You can obtain warranty parts direct from Heath Company by writing or telephoning us at (616)982-3571. And we will pay the shipping charges to get those parts to you...anywhere in the world.

SERVICE LABOR — For a period of one year from the date of purchase, any malfunction caused by defective parts or workmanship will be corrected at no charge to you. You must deliver the unit at your expense to the Heath factory, any Heath/Zenith Computer and Electronic Center (units of Ventechonology Electronics Corporation) or any of our authorized overseas distributors.

TECHNICAL CONSULTATION — You will receive free consultation on any problem you might encounter in the use of your Heath product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

NOT COVERED — Repair service, adjustments and calibration due to misuse, abuse or negligence are not covered by this warranty. Unauthorized modification of the product or of any furnished component will void this warranty in its entirety. This warranty does not include reimbursement for inconvenience, installation, set-up time, loss of use, or unauthorized service.

This warranty covers only Heath assembled products and is not extended to other equipment and components that a customer uses in conjunction with our products.

SUCH REPAIR AND/OR PARTS REPLACEMENT SHALL BE THE SOLE REMEDY OF THE CUSTOMER AND THERE SHALL BE NO LIABILITY ON THE PART OF HEATH FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOSS OF BUSINESS OR PROFITS, WHETHER OR NOT FORESEEABLE.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

OWNER'S RESPONSIBILITY

EFFECTIVE WARRANTY DATE — Warranty begins on the date of first consumer purchase. You must supply a copy of your proof of purchase when you request warranty service or parts.

OPERATING MANUAL — Read your operating instructions carefully so that you will fully understand the proper operation and function of your unit.

ACCESSORY EQUIPMENT — Performance malfunctions involving connections to (or interfacing with) other non-Heath equipment are not covered by this warranty and are the owner's responsibility.

SHIPPING UNITS — Follow the packing instructions published in your manual. Damage due to inadequate packing cannot be repaired under warranty.

If you are not satisfied with our service (warranty or otherwise) or our products, write directly to our Director of Customer Service, Heath Company, Benton Harbor MI 49022. He will make certain your problems receive immediate, personal attention.